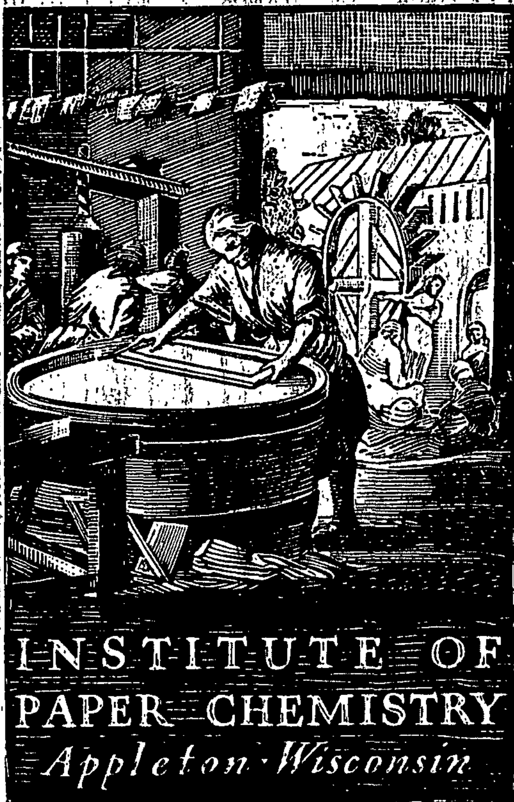

AN INVESTIGATION OF LINTING AND FLUFFING OF OFFSET NEWSPRINT

Project 2949

Report Four

A Progress Report

to

MEMBERS OF GROUP PROJECT 2949

August 23, 1974

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

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MEMBERS OF GROUP PROJECT 2949

Bowater Incorporated

International Paper Company

Southwest Forest Industries, Inc.

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THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

AN INVESTIGATION OF LINTING AND FLUFFING OF OFFSET NEWSPRINT

SUMMARY

Comparative linting tests conducted with fresh supplies of newsprint from the cooperating companies showed no significant differences in linting tendency from previous papers for two of the three companies but a marked increase in linting by the paper from the third company. A new technique for photographically recording the position of lint particles on the plate for comparison with the final prints, confirmed the detrimental effect of these particles upon print quality. However, gravimetric determination showed the amount of plate lint to be small in comparison to blanket lint for all the papers. Heavy accumulations of blanket lint in halftone areas interferes with the faithful reproduction of the intended screen tint and the effect upon print quality becomes most obvious when the blanket lint is unevenly distributed within a uniform tint area.

The effects of several lithographic variables upon linting tendency were investigated. In plates containing only solid printing and nonprinting areas (no screen tints), blanket lint decreased with decreasing printing area but ink train lint increased to a lesser degree so the total lint also decreased. This suggests that both image and nonimage blanket areas remove lint from the paper but that lint picked up by image areas is more likely to contribute to blanket lint and lint from nonimage blanket areas is more likely to be released to the ink train. More lint is deposited with alkaline fountain solution than with acid fountain solution when the plate has a preponderance of image area but the reverse is true when the plate has a preponderance of nonimage area. The advantage of alkaline fountain solution with the largely nonimage plate for reducing blanket lint was particularly apparent in longer press runs.

Throughout the runs the tendency for the press to classify the lint with the ink train being somewhat coarser than the blanket lint is apparent. In order to investigate the mechanism of linting, lint transport and classification, comparative linting tests were conducted by offset lithography and letterset (relief offset). To determine whether the differences between the offset lithography and letterset results were due to the elimination of water or to the physical separation between plate and blanket in nonprinting areas, another condition, in which water was applied to a relief plate, was also included. The importance of water was indicated by the much smaller quantity and the much reduced coarseness of the lint when letterset (without water) was used to print the paper which had provided the greatest quantity and the coarsest lint. A hypothetical mechanism has been proposed suggesting that the effect of water is to modify the lint fibers in a manner which reduces the probability of coarse fibers being lost by transfer from the blanket to the paper.

On the assumption that the above mechanism is valid, a method of determining linting tendency in the laboratory using the IGT printability tester and polyisobutylene as the ink simulant, without water, has been developed. This laboratory method can be used gravimetrically for quantitative determinations or the deposits can be compared visually. In either case they rank the three papers in the same order as the offset press evaluations. Comparison of press test evaluations with the laboratory linting tests for a larger number of papers is needed to establish the utility of the method.

INTRODUCTION

Report One of this project described the development of press test methods utilizing the Apollo web-fed offset press for gravimetric determination of the blanket and ink train lint deposited by offset newsprints. Report Two reported comparative linting tests of sponsors newsprints and attempted to relate the print quality to the amount of lint deposited. Correlation between quality and amount of lint was poor and it was suggested that this was at least in part due to the serious quality degradation caused by a few coarse lint particles which tended to adhere to the plate when certain of the papers were printed. Report Three described a microscopic investigation of the fiber furnish and the lint deposited in these printing trials. It was shown that print quality degradation was related to the general coarseness of the lint and to the quantity of lint found in the ink train.

As a result of a meeting of member companies at which the three reports were discussed, a new program was proposed and approved by the cooperating companies. This program included (1) further linting tests under a wider variety of conditions with added emphasis on the relationship of plate lint to print quality, (2) study of the linting mechanism, (3) further characterization of the lint which accumulates at various locations in the press, and (4) investigation of means for convenient linting tests which do not require an offset press. The first three phases of this program have been undertaken concurrently and are described in Part I of this report. Part II describes a laboratory linting test employing the IGT printability tester. This test follows logically from the mechanism of linting proposed in Part I.

PART I. PRESS TESTS WITH THE APOLLO PRESS

EXPERIMENTAL DETAILS

Papers

New lots of newsprint were obtained from each cooperator and were provided with Codes J, K, and L. Each of the member companies is being informed of the code letter for that company. The number following the letter code indicates which of the duplicate rolls was used in a particular experiment.

Fiber analysis data for these papers are reported in Appendix I. Paper J does show a different fiber composition than its predecessor.

Printing tests were restricted to the felt sides of these papers.

Relief Printing Plates

A relief printing plate comprising a continuously connected printing area and circular isolated nonprinting areas was prepared by punching 1/4-inch holes in a rhombic pattern on 3/8-inch centers along horizontal and oblique axis which were separated by 70°. In theory this pattern provides 62.8% printing area. However, when margins, a slightly greater center line separation and a hole which was purposely omitted to facilitate the determination of image orientation are considered there are 58.6 in.^{2} of printing and 21.4 in.^{2} of nonprinting area within the 8 by 10-inch area corresponding to the area of the blanket from which blanket lint was collected. This corresponds to 73.25% printing area in this 8 by 10 area of principal concern. However, the margins beyond this area to the 12-inch width of the paper and to the gap in the 8 1/2-inch cylinder circumference are also printing areas. The ink fountain, however, was closed beyond the 10-inch test width and this permitted the ink coverage to "feather out" toward the edges of the 12-inch paper web. A photograph of a letter-set print of this plate is shown as Fig. 1A. Differences between this image and those from the other circle image plates which were used will be apparent from comparison with the other three photographs in this figure. In all cases the location of the 8 by 10-inch blanket lint isolation area is shown by ruled lines.

A similar relief plate was made by punching holes from a processed offset plate having a central 8 by 10-inch lithographically ink receptive area surrounded by lithographically water receptive area. This plate was used with lithographic dampening to print an image identical to that printed by the other relief plate except that margins outside the 8 by 10-inch central area were non-printing rather than printing areas as illustrated in Fig. 1B.

Images of the type printed by these relief plates will be referred to as open circle plates because of the open (or nonprinting) circles in continuously connected printing area.

Lithographic Plates

The punched out relief plate was used as a stencil to prepare a photographic negative from which an open circle offset lithographic plate was prepared. The margins of this plate beyond the central 8 by 10 image area were masked to make them nonprinting as is illustrated in Fig. 1C.

A contact positive, in which the light and dark areas of the negative were reversed, was prepared from the negative and this was used to prepare an offset lithographic plate which printed inked circles within the central 8 by 10-inch area of a continuously connected nonprinted area. This image is referred to as the inked circle image and is illustrated in Fig. 1D.

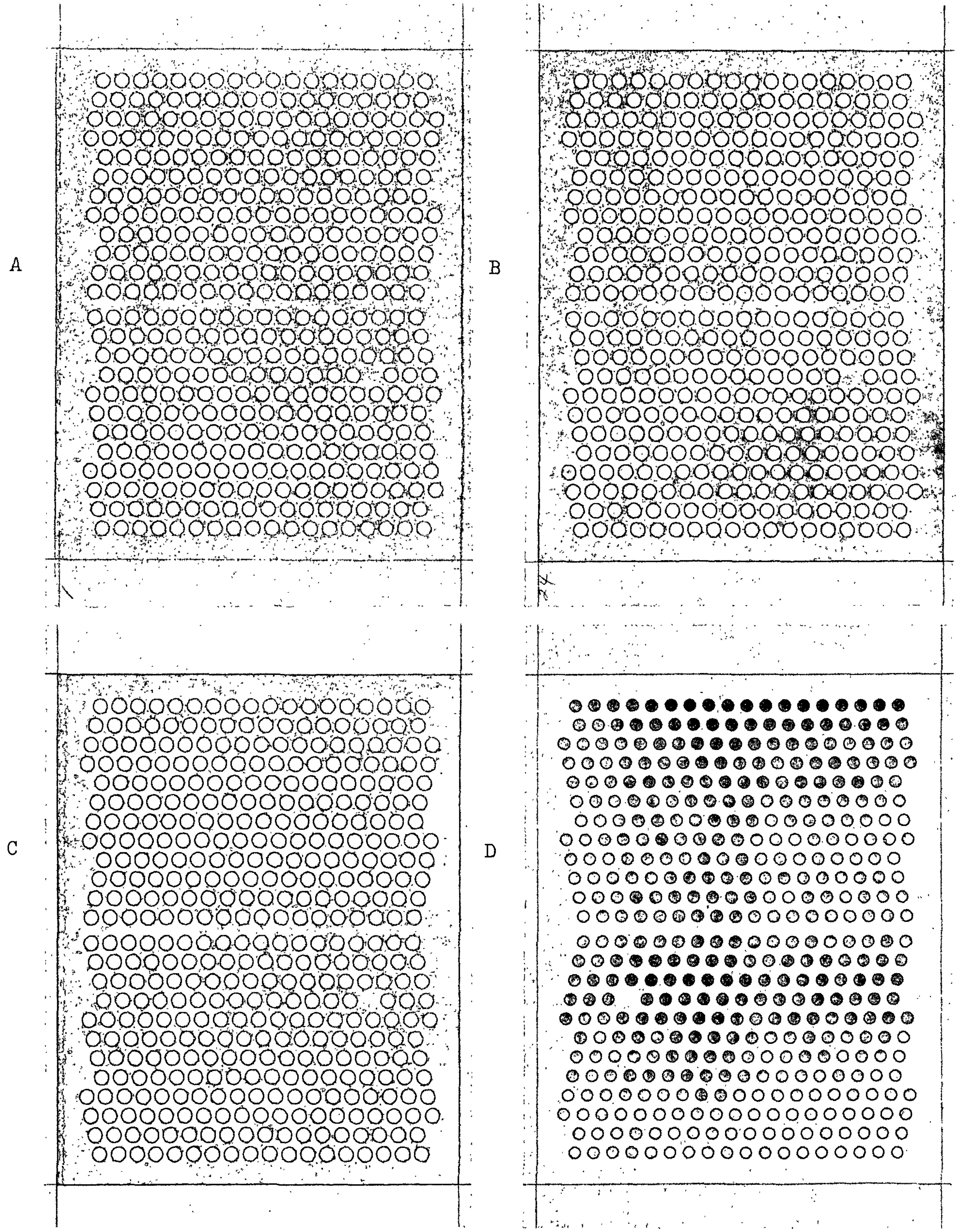

Figure 1. Photographs of Prints Made by Different Printing Methods and Images. The Location of the 8 by 10-Inch Blanket Lint Isolation Area is Indicated by Lines. A. Letterset Open Circle. B. "Relief Lithographic" Open Circle. C. Offset Lithographic Open Circle. D. Offset Lithographic Inked Circle

In addition, the previous lithographic image of Report One which contains 20, 50, 70, and 90% halftone tints at 120 lines/inch separated by 1/4-inch solid bars was used. When this was used the area of blanket from which lint was isolated was reduced to 20 by 24 cm. This area includes not only the halftones and solid image but some nonprinted margin including reference letters and numerals. The printing area (neglecting the area of numerals and letters) is calculated to be 48.7% of the isolation area. This image is referred to as the halftone and solid image.

EXPERIMENTAL RESULTS

The data from all of the press tests for linting are shown in Tables III-V in Appendix II. The run numbers provide a record of the order in which the tests were conducted but the data have been grouped in the table to collect similar experiments and to facilitate comparisons. These quantitative linting tests with the Apollo Press were conducted both for evaluation of the new paper samples and also to clarify the mechanism by which lint is accumulated and transported in the offset press.

Comparison of Papers

Comparison of Linting Tendency

Runs 1-9 comprise linting tests of the three new papers under the test conditions previously adopted (2500 impressions, acid fountain solution) except that a new open circle plate image was used instead of the halftone and solid image which was used in previous tests. In addition to blanket and ink train lint, which were collected as in previous tests, the lint on the plate was removed with adhesive coated film, photographed to provide a record of the location of lint particles, and, when possible, then determined gravimetrically. Three tests were made on the felt side of each paper using a different roll for each test. In the case of Papers K and L, agreement between runs was good. In Runs 6 and 8 on Paper J, flakes of colored lint were found between sheets in the delivery stock and this provides a probable explanation for the lower amount of lint isolated from these runs than from Run 1. Consequently, it was concluded that there is no evidence of roll-to-roll variation within the supply of these papers. The relative amounts of lint (blanket lint and ink train lint) obtained in these tests and in single tests using the original halftone and solid test image are compared graphically in Fig. 2. The agreement in the amount of lint collected with these two different test images is considered to be remarkable in view of the great difference between the images. Single tests with the new open circle image and alkaline fountain solution (Runs 25-27) provided somewhat more lint than the acid fountain solution but there was no change in the relative linting tendency of the three papers. It will be noted later that the comparative lint amounts with acid and alkaline fountain solutions are dependent upon the plate image and the length of run.

The current linting data (tests with the original halftone test image) are compared in Fig. 3 with the test results previously obtained (Report Two) on the earlier papers supplied by the same companies. It is apparent that Paper J deposits a great deal more lint than the previous Paper AO. There is no significant difference between either Paper K or Paper J and the newsprints previously supplied by the same manufacturer. It was noted earlier that Paper J was the one which showed a different fiber composition than the original paper from the same source.

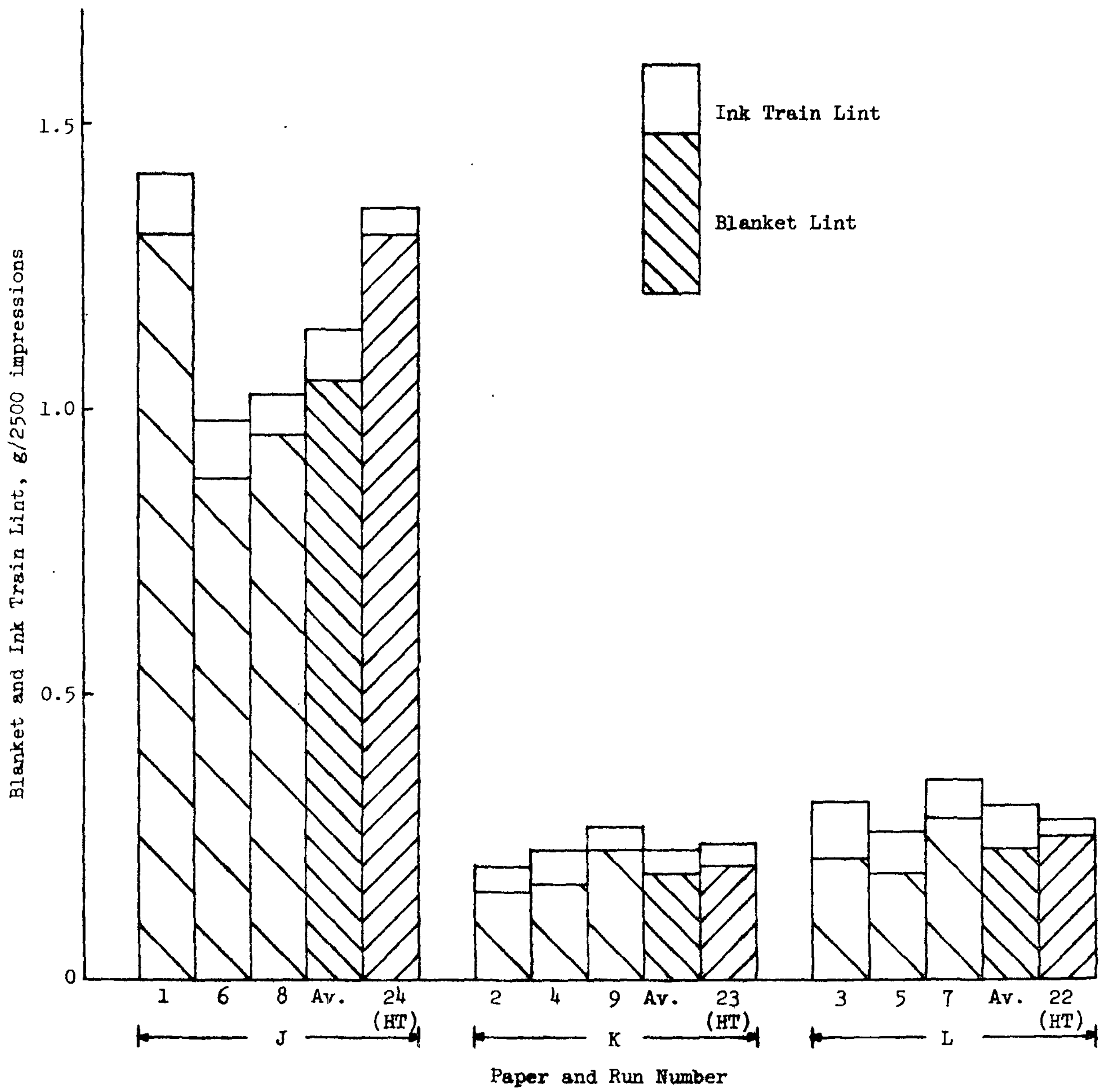

Figure 2. Comparative Linting Determinations for the Felt Sides of Papers J, K, and L. Triplicate Runs and Averages (Av) Compared to Single Runs with Halftone and Solid (HT) Image

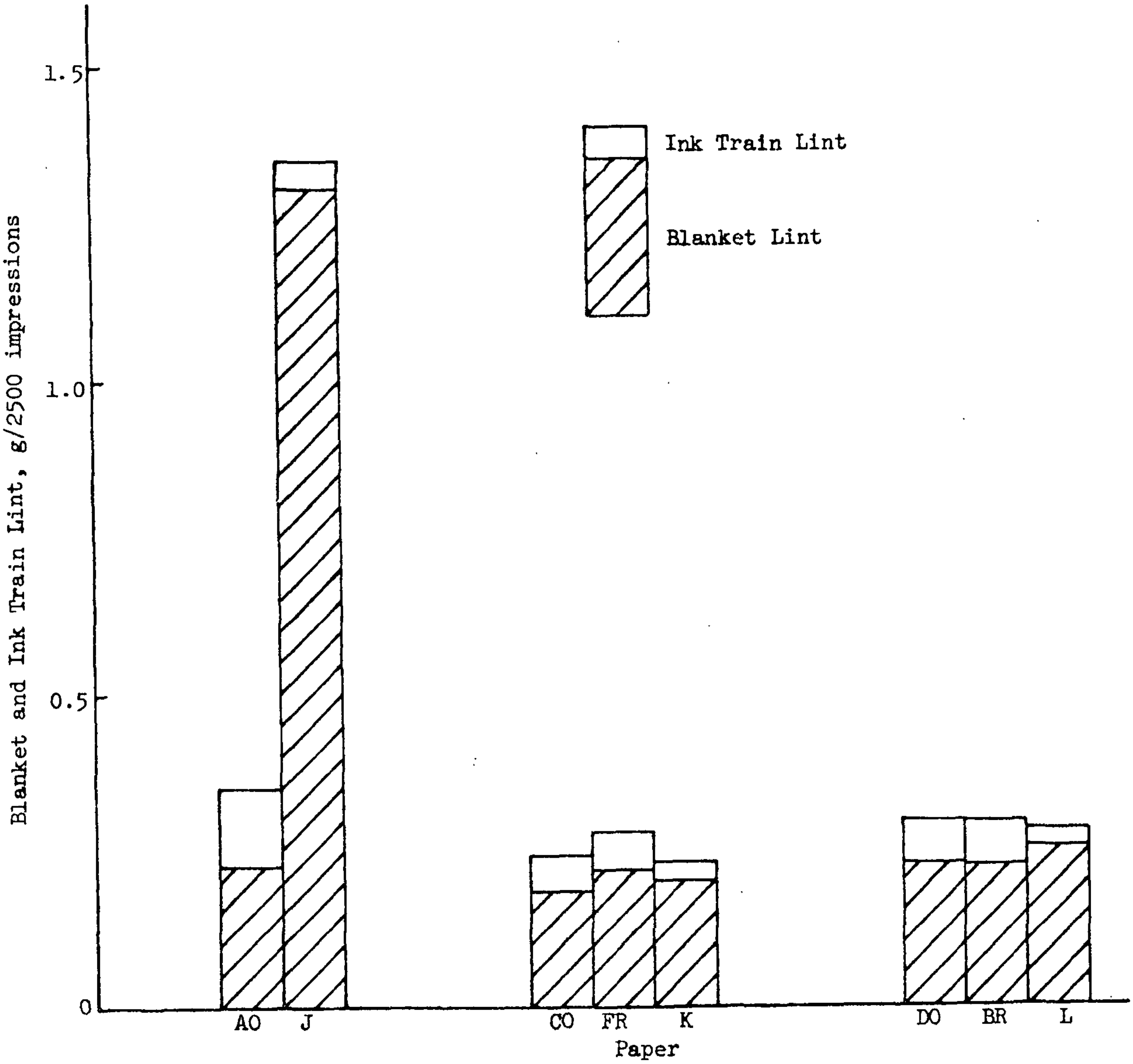

Figure 3. Comparative Linting Determinations for the Felt Side of Papers J, K, and L Compared with Previous Results with Papers from the Same Source. All Determinations with the Halftone and Solid Image

Effect of Lint on Print Quality

The photographic prints showing the plate and blanket lint distribution have been compared with the end-of-run printed product to relate the presence of lint to noticeable degradation in print quality. This has been most useful when the original halftone image was used. Noticeable discontinuities in print image could almost always be traced to plate lint accumulation. For example, 21 of 25 print defects which were investigated on the end-of-run print from Run 22 were traced to coarse fibers which were evident in the plate lint photograph. Appendix III contains the end-of-run print and plate lint photograph for the reader's comparison. Therefore, the previous conclusion that plate lint is particularly injurious to print quality has been confirmed. However, extremely heavy deposits of blanket lint such as were encountered with Paper J reduced the fidelity with which the screen tints were reproduced. This was most noticeable in Run 24 where tints printed heavier from lint covered areas than from adjacent areas which had lost their lint. This resulted in a severely mottled appearance. The end of run press print and photo of blanket lint are found in Appendix III. The end-of-run quality on Paper K was superior to that on either Paper J or Paper L in that it was relatively free of the defects due to coarse plate lint particles or the mottle due to heavy, uneven deposits of blanket lint.

Printing quality differences were more evident when the original halftone and solid plate image was used. Therefore, inclusion of halftones is recommended for comparative linting tests. However, the new open circle plate has been useful for investigation of the linting mechanism.

Investigation of the Linting Mechanism

Letterset or "dry offset" printing conditions provide blanket to paper contact similar to offset lithography but the use of the relief plate eliminates the need for water and the whole dampening system. Comparison of linting tests by offset lithography and letterset, therefore, offers a means for determining the role of water in linting on offset presses. By use of a plate of the same thickness as the offset plate as the printing "relief" surface and punching holes to form the nonprinting valleys it was possible to print by letterset even with the shallow undercut of the cylinder of the Apollo Press. However, in addition to eliminating water and the dampening rolls, the change to letterset isolates the plate from the blanket in nonprinting areas. As a result, transport of lint in either direction between blanket and ink train by nonimage plate areas, which can occur in offset lithography, is not possible by letterset. To independently determine the effect of this isolation of the nonprinting plate areas in the presence of water another printing condition, which we will refer to as "relief lithographic conditions" was employed. A relief plate having a lithographic ink receptive printing surface and punched holes as the nonprinting valleys was used in combination with regular lithographic dampening. This printing condition is of no practical value and was used only to separate the effects of the changes which were simultaneously introduced by letterset printing.

Test data for printing the same test image under these three printing conditions (Runs 13-18 letterset; Runs 10-12 and 19-21 "relief lithographic"; Runs 1-9 offset lithographic) are compared in Tables III-V, Appendix II. The more important differences are shown graphically in Fig. 4. It is evident that the greatest differences due to printing method occur with Paper J which is the paper of greatest linting tendency. Blanket lint which decreases drastically from offset lithography to letterset for Paper J also decreases modestly for the other two papers. In the case of Paper J and Paper K this decrease is accompanied by an increase in ink train lint. In all cases the greatest amount

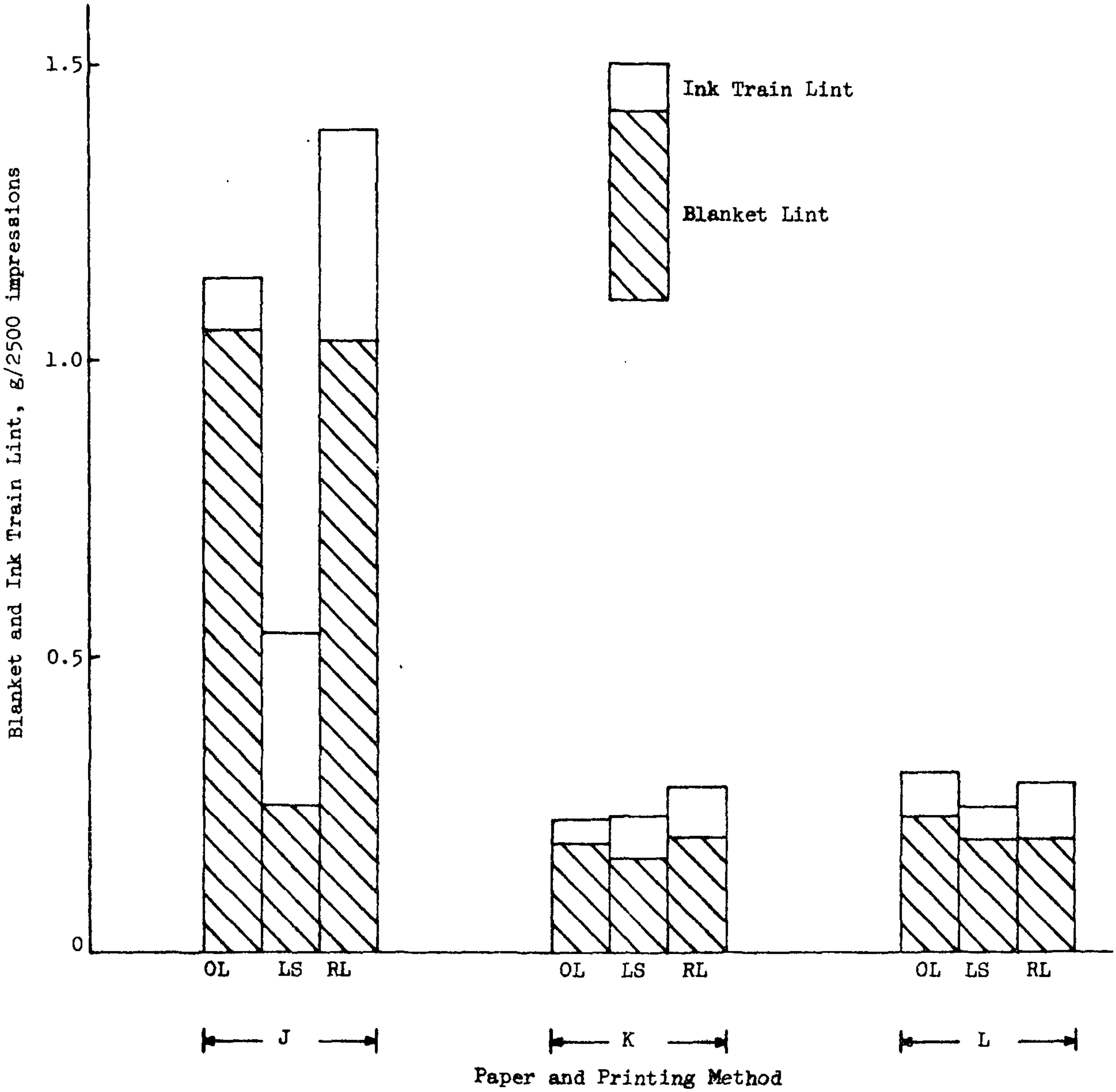

Figure 4. Amount of Blanket and Ink Train Lint from the Felt Side of Papers J, K, and L Under Offset Lithographic (OL), Letterset (LS), and "Relief Lithographic" (RL) Printing Conditions

of ink train lint is encountered under relief lithographic conditions. The letterset condition also reduces the coarseness of the lint. This is strikingly evident with the blanket lint from Paper J but it is also detectable in the ink train lint from this paper and in the blanket and ink train lint from the other papers. Photomicrographs of lints from several runs are shown in Appendix IV. In contrast, lint from tests run under relief lithographic conditions does not differ appreciably from that obtained under normal offset lithographic conditions. It is evident that water plays an important role in lint accumulation — particularly when Paper J is used.

It is of interest to learn the relative importance of the ink and water-bearing areas of the blanket in the removal of lint from paper. Larsson (1) and Jansen (2) have both observed linting to increase with the fineness of screen ruling and to be greatest for a given ruling at a 50% area tint. Jansen has suggested that the boundary length between ink bearing and water-bearing image elements is the critical factor. If this is true it is surprising that approximately equal amounts of lint were obtained with the original 120-line halftone image and the new image of 1/4 inch open circles (which is approximately equivalent to a 63% tone at 2.7 lines/inch). The original halftone image has more than 30 times the length of boundary between the ink and water-bearing areas. Reexamination of the linting data (Fig. 2) shows that, although the total lint collected did not differ significantly, a consistently larger portion of the total lint was found in the ink train when the new open circle plate was used.

To further investigate the effect of ink-bearing and water-bearing areas on linting the circle image was reversed photographically to produce inked circles on an open background and linting tests were conducted with both types of circle image. The results with both acid and alkaline fountain solution are shown in Table I. The decreased inked area of the inked circle image results in a considerable decrease in blanket lint and a smaller increase in ink train lint with a resulting decrease in total lint regardless of the fountain solution used. It is clear that the results cannot be ascribed to either the ink-bearing or water-bearing blanket being wholly responsible for picking of lint from the paper. It would appear, however, that lint picked up by inked areas of the blanket has the greater probability of being found on the blanket and that lint picked up by water-bearing areas of the blanket has the greater probability of being found in the ink train.

TABLE I

EFFECT OF PLATE IMAGE, FOUNTAIN SOLUTION AND LENGTH OF PRESS RUN ON BLANKET, INK TRAIN AND TOTAL LINT FROM PAPER K

Impressions of Press	Plate Image	Acid Fountain Solution	Alkaline Fountain Solution
2500	Open circle (I/NI = 58.6/21.4)	0.1526 g Blanket 0.0186 g Ink train 0.1712 g Total	0.1584 g Blanket 0.0436 g Ink train 0.2020 g Total
2500	Inked circle (I/NI = 21.4/58.6)	0.0767 g Blanket 0.0775 g Ink train 0.1542 g Total	0.0702 g Blanket 0.0657 g Ink train 0.1359 g Total
7500	Inked circle (I/NI = 21.4/58.6)	0.1682 g Blanket 0.1032 g Ink train 0.2714 g Total	0.0951 g Blanket 0.1946 g Ink train 0.2897 g Total

The greater amount of lint accumulated when alkaline rather than acid fountain solution was used with the open circle plate image is in agreement with previous test results for this image (Runs 25-27 vs. Runs 1-9). However, with the greater nonprinting area of the inked circle plate the result is reversed. It appears that the alkaline fountain solution is more effective on nonprinting areas than on printing areas in so far as control of blanket linting is concerned. The longer runs (7500 impressions) with the inked circle image show that the alkaline solution has a greater tendency to transport the lint from the blanket to the ink train and thereby to reduce the rate of buildup of lint on the blanket.

DISCUSSION OF THE MECHANISM OF LINTING

A knowledge of the mechanism of lint accumulation and transport can be of importance to the manufacturer of offset printing papers in two respects. First, it may indicate the type of changes that would improve papers with respect to linting tendency. Second, it should indicate the characteristics of the offset press which must be simulated by a laboratory linting test if it is to provide useful estimates of linting potential. Many questions remain to be answered before the processes involved in linting can be described with confidence. However, enough has been learned that it seems worthwhile to attempt to construct the most reasonable hypothetical mechanism to explain the observations which have been made. It is recognized that more than one possible explanation for some of the observations exist, so it is expected that the mechanism suggested will require revision.

It is useful to consider the various pathways through which lint may travel throughout the press. Figure 5 schematically shows how the two parallel pathways comprising the image and nonimage areas of paper, blanket and plate, terminate in the common pathways of the inking and dampening systems. Lint is visualized as traveling in both directions through these pathways. The contact of inking form rollers and dampeners* with both image and nonimage areas of the

*This statement applies to the Apollo Press. In certain cases such as with the Goss Metro press where brush dampeners are used the dampening system makes no contact with the plate cylinder and cannot transport lint. For such press systems the dampening system should be eliminated from Fig. 5.

plate provide means whereby lint can travel between the image and nonimage systems. Consequently, it is possible that lint which is found in image areas of the plate or blanket may have originated from nonimage areas of the paper and the reverse is also true. Evidence for transport from the image pathway to the nonimage pathway is provided by the experiments with letterset and relief lithographic conditions. In these cases transport of lint from paper to plate by nonimage blanket areas is precluded by lack of contact between blanket and plate in these nonimage areas. Nevertheless the inking rollers, which bottom against the bare plate cylinder in the central part of the nonimage hole area, do deposit lint in these nonimage areas. Clearly this lint must be carried to the ink distributing system by image areas of the blanket and plate.

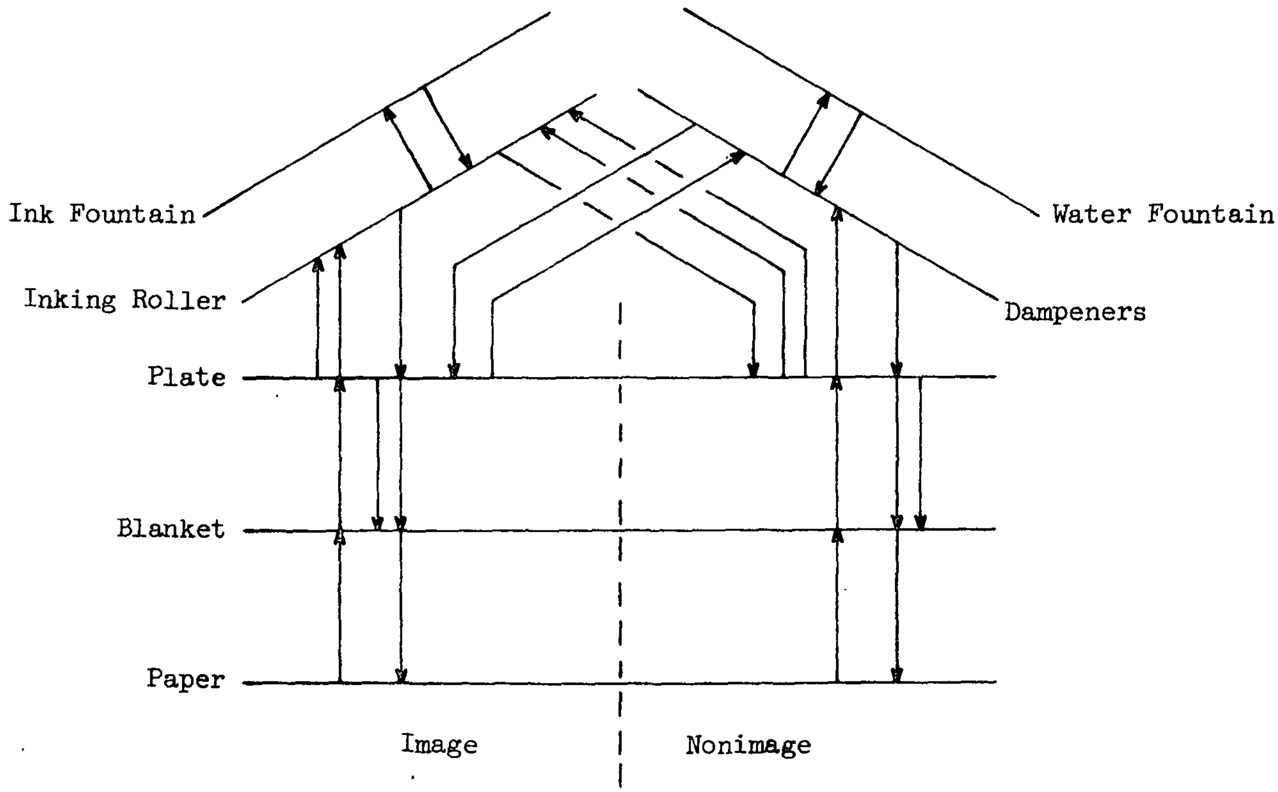

Figure 5. Pathways for Lint Transport in the Apollo Press

It should be clear that a low level of lint found at any location within the press has little bearing upon the importance of that element on the transport of lint. For example, little lint is found on the offset printing plate but all of the lint found in the ink distributing system (and in the dampening system) must have been transported by the plate. This is understandable if we assume a much higher probability for transport from the plate to the blanket and to inking (and dampening) rollers, rather than for the reverse direction. This is indicated by the double arrows of Fig. 5.

In view of the dissimilar surfaces which meet in the various press nips it is not surprising that a considerable degree of classification of lint occurs within the press. Ink train lint is coarser than blanket lint, while plate lint is coarser than both. In addition, a considerable amount of lint containing a significant proportion of chemical fibers, as well as very coarse groundwood shives, was found in the ink fountain after the letterset run with Paper J. Hence, it is shown that the press distributes the lint in order of increasing coarseness as follows: blanket lint, ink train lint, plate lint and ink fountain lint. This order of coarseness is unchanged when printing conditions, viz., offset to letterset, are modified, although relative coarseness of lints from the same collection point are modified. Ink fountain lint was also determined and found to be negligible in the extended (7500 impressions) lithographic runs on Paper K. However, the small amount of lint recovered was coarser than lint from other collection points. Since ink fountain lint was not determined in any other runs it is not possible to state whether these results were due to the greatly differing quantity and coarseness of the lints from these papers, or to the effect of water on the transport and classification of the lint by the press. Photomicrographs of lints collected from a number of runs are shown in Appendix IV.

It is assumed that transport of lint between paper and blanket occurs in both directions and that loss of lint to the paper as well as pick-up of lint from the paper can have a significant effect on the amount of lint present in the press. It is sometimes observed that a large flake of colored lint becomes detached from the blanket and is found between the sheets or printed product in the delivery stock. This is observed only with papers that are heavy linters but one would not expect to see colored individual lint particles if they were redeposited in the printed image or uncolored particles if they were redeposited in nonprinted areas of the paper.

Some of the transport steps schematically shown by arrows in Fig. 5 may seem highly improbable. For example, it seems unlikely that an ink covered lint particle would transfer from an inking roller to the wet nonimage area of the plate which is not ink receptive. For such transfer to occur would require that the lint particle be rendered hydrophilic by exposure to fountain solution. Under such conditions a buildup of colored lint might occur on the nonimage areas of the blanket. Such deposits have not been observed in any of the test runs in the laboratory but they did occur during observation of a lengthy commercial trial.

The results of press trials made under letterset, relief lithographic and offset lithographic conditions clearly indicate that water affects the amount and coarseness of the lint deposited, particularly when papers which can provide a high concentration of coarse lint are printed. Two tentative explanations for this finding are possible: First, the water may increase the number of lint particles (and particularly coarse lint particles) which are picked up by the blanket or second, the distribution, classification and retention of the lint particles may be modified by interaction between lint and water after the lint has been picked up by the press.

There are several ways in which water might conceivably affect lint pick-up. Water is known to reduce the tack of inks but this would reduce the stress applied by the splitting ink film and should, therefore, reduce lint pick-up. Moisture in nonimage blanket areas might improve the contact with paper and thereby increase the stress applied in these areas. However, in the case of the experiments under relief lithographic conditions, the relief plate should not supply moisture to the nonimage blanket areas. The effect of water upon the paper should, therefore, be limited to the margins between printing and non-printing areas and to water carried on or in the ink film. Water is known to dis-rupt fiber-to-fiber bonds of paper but the contact time between the blanket and the paper is less than 0.01 sec even at the relatively slow speed of the Apollo Press. It does not seem reasonable to expect a small amount of water, supplied to the upper surface of the bonded fiber mat, to migrate to the bonding site and weaken the bond within this short period of time. For these reasons the first of the two tentative explanations offered above does not appear to provide a valid reason for the observations.

The second tentative explanation, that water affects the lint particles after they are picked up by the press, is supported by the known effect of water on paper fibers and by the ample time during which such interaction can occur. Water can be expected to increase the flexibility, and the hydrophilic character of the fiber surfaces. Therefore, it is of interest to consider how these changes might affect the way the fibers are transported and retained by the press. The fate of a small particle of lint in a nip containing ink, may depend upon its location with respect to the position at which the ink film splits at the exit side of the nip. However, large lint particles will usually extend on both sides of the plane at which the film would normally split and, therefore, can influence the actual splitting position. They will tend to adhere to the surface to which they make the most intimate contact. Large, stiff fibers and fiber bundles will not conform well to any surface, and in addition may be dislodged by a rocking movement as they pass through a nip. However, as they absorb water they become more conformable and flexible and less likely to transfer. Small particles of lint in the portion of the ink film not transferred should have a probability for transfer which is less affected by the presence of moisture. On the basis of this reasoning, it may be expected that papers with little coarse lint will provide lint deposits which are similar in amount and size distribution, whether they are printed under letterset, normal lithographic or relief lithographic conditions. However, when the paper has many poorly bonded large fibers and fiber bundles, smaller deposits are obtained by letterset than by the other printing conditions and the lint is finer because of the more extensive loss of the coarser fiber fraction by transfer back from the blanket onto the paper. Such a mechanism provides a reasonable explanation for the considerable difference in amount and character of lint collected from Paper J under the three printing conditions and for the relatively minor differences in lint from either Paper K or Paper L under the same conditions.

The experiments with the open circle and inked circle plates under normal lithographic conditions provide some information concerning the relative effectiveness of solid image and solid nonimage blanket areas in picking up lint from the paper. It must be concluded that both types of area are involved and that a large proportion of image area favors accumulation of blanket lint and that a large proportion of nonimage area favors the retention of ink train lint. A relatively small proportion of the lint picked up by these particular areas would be in a position to simultaneously contact both inked and noninked blanket area but the proportion of such lint would increase greatly if a halftone image was used. Numerous prints of blanket lint for experiments with the original halftone and solid bar image provide evidence that even more lint is retained in 50 and 70% halftone areas than in the solids. This might be explained by some loss of lint from the solid image area of the blanket to the paper (by the same means as described above for letterset printing) before the stiffness and conformability of the particle were sufficiently modified by the aqueous fountain solution to improve its chances for retention. Because of this possibility, it seems wise to return to a press plate containing a large portion of halftone image area for any further press linting studies.

It should be noted that regardless of the printing method (letterset, normal offset lithography or relief lithography), the plate (halftone and solid bars or 1/4-inch open circles in solid image), or the fountain solution (acid or alkaline), the linting tendency of the three papers was in the order J >> L > K, although the distinction between J and L was reduced when printed by letterset. Similarly, the lints collected from the same paper were similar except for the marked reduction in coarseness when Paper J was printed by letterset. An explanation has been offered in which the letterset differences have been attributed not to differences in pick up of lint but to differences in the tendency to lose the lint already picked up to the paper on subsequent impressions. If this explanation is correct, a simple printing test with an ink simulant without water should provide a satisfactory estimate of relative linting tendency provided the lint is collected from the printing surface after each impression before it can be retransferred back to the paper. Part II of this report describes an evaluation of this idea.

PART II. LABORATORY LINTING TESTS

EXPERIMENTAL DETAILS

Laboratory Linting Test

The IGT printability tester was motorized to run at the constant speed of 17.8 cm/sec and the sector was covered with a piece of offset blanket. The 2-cm wide printing disk was coated with 5 g/m^2 of polyisobutylene of known viscosity, using the distributing system. Strips of paper (of such length the total circumference of the disk printed without overlap) were printed in the machine direction. Polyisobutylenes having viscosities of 349, 863, and 1900 poise were used. These conditions were so mild that no pick failure was evident in the printed sample. After each printing the residual polyisobutylene containing any lint which was picked up from the paper was removed with a razor blade. The total residual oil remaining after printing 25 strips (1000 cm^2 of sample) was dissolved in petroleum ether and filtered through a tared medium porosity filter crucible. After washing twice with petroleum ether, once with ethyl alcohol and finally with water, the crucible containing the lint was dried one hour at 90°C and conditioned one hour at 73°F and 50% RH before weighing.

In other experiments the amount of lint was ranked visually rather than determined gravimetrically. For this purpose only 5 paper strips were printed and the lint was collected by filtration on filter paper which had been blackened with Chlorazol Black E dye. The lint was confined to a fixed area on the filter by application through a 41-mm glass tube. Photographs at 4X (which correspond approximately to the enlargement of the specimen as viewed through a hand glass) are shown in Appendix V.

EXPERIMENTAL RESULTS

The weight of lint obtained from 1000 cm^2 of each of Papers J, K, and L with polybutenes of 349, 863, and 1900 at a constant speed of 17.8 cm/sec [velocity viscosity product (VVP) 6.2, 15.4, and 33.8 kp cm/sec] is shown in Table II. At the lowest viscosity the amount of lint was not adequate to provide reliable weights. The relative results of the experiments at the two higher viscosities, (taking the value for Paper K as 1.00), are shown in Fig. 6 in comparison with similar relative values for the three different offset lithographic conditions under which the papers were tested. It is evident that the IGT test ranks these papers in the same manner as the press tests and actually provides somewhat better separation between the papers than the press tests.

TABLE II

GRAVIMETRIC DETERMINATION OF LINT ISOLATED
FROM THE MODIFIED IGT TEST

Printing Medium	Velocity Viscosity Product	Lint Collected, g		
		Paper J	Paper K	Paper L
News ink	--	0.0018	0.0011	-0.0002
Polybutene				
349 poise	6.2	0.0006	0.0005	-0.0003
863 poise	15.4	0.0086	0.0005	0.0010
1900 poise	33.8	0.0374	0.0036	0.0067

Visual examination of the lint from 5 specimens of each paper on blackened filter paper also ranked the three papers in the same order as can be appreciated by comparing the 4X photographs shown in Appendix V.

It was of interest to determine whether the lint obtained with this laboratory test with the IGT instrument corresponded in character to that obtained in the Apollo Press tests. Microscopic examination revealed that at

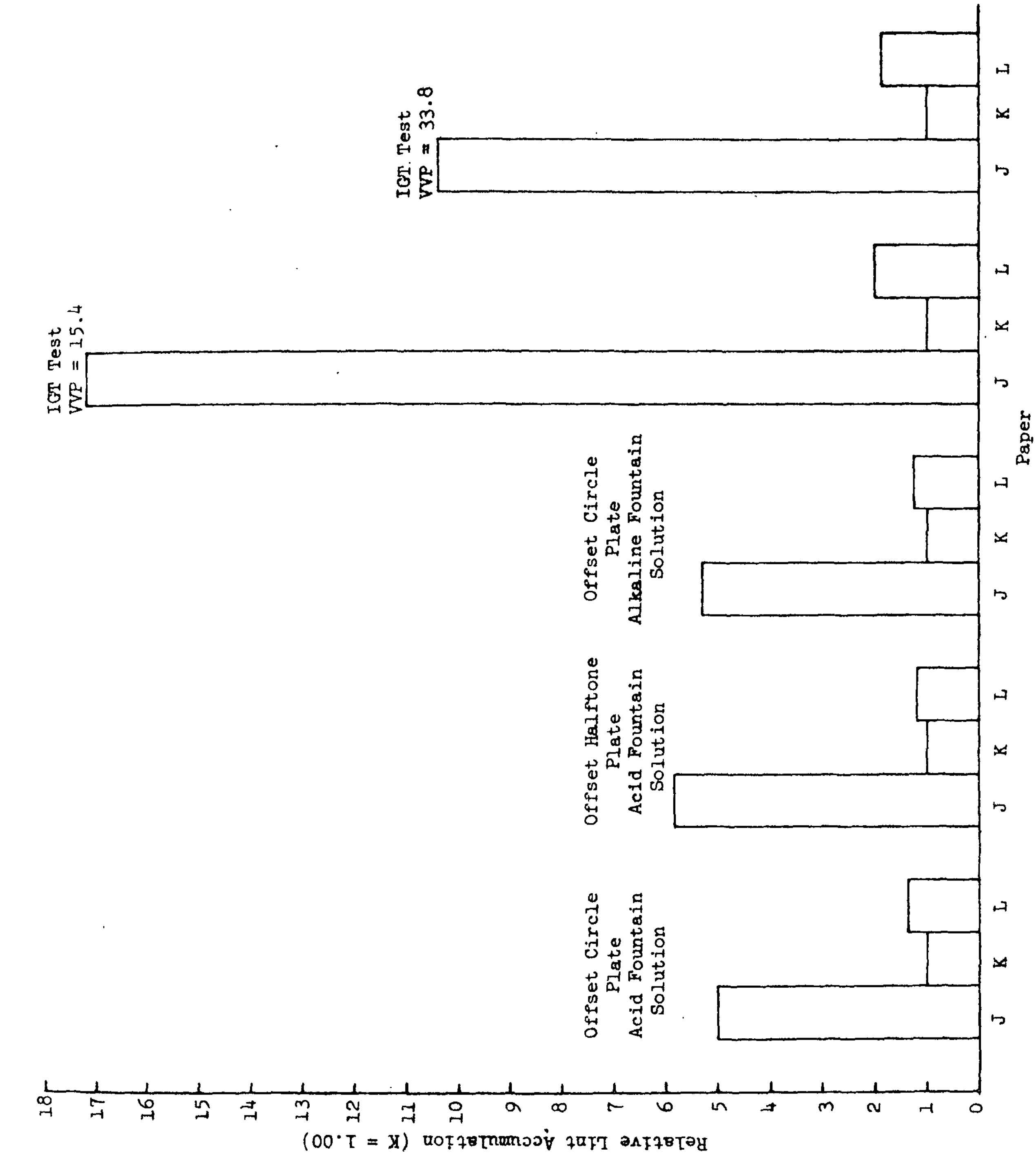

Figure 6. Relative Amounts of Lint Collected from Papers J, K, and L by the IGT Tests and Offset Printing Tests

the lowest viscosity the small amount of lint from each paper was similar to, or finer in fiber character, than that obtained in press tests. However, at 863 poise the lint from Paper J began to resemble the whole fiber from this paper and even Paper L provided some fibers that were coarser than press lint. At the highest viscosity used, all the papers deposited some fibers which were generally absent from press lint, and this indicates the stress applied to the sheet exceeds that of the Apollo Press. Further work with a greater number of papers will be required to determine the viscosity of polybutene which provides results which correlate with press tests and collects a convenient quantity of lint which is similar to that deposited during press operation.

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THE INSTITUTE OF PAPER CHEMISTRY

Betty John

Betty John, Research Fellow

Russell F. Tyler

Russell F. Tyler, Research Fellow

Robert M. Leekley

Robert M. Leekley
Senior Research Associate
Division of Natural
Materials & Systems

APPENDIX I

FIBER ANALYSIS OF COOPERATOR'S PAPERS

PAPER J

47% Softwood lightly bleached kraft. Principal species Douglas-fir and southern and/or jack pine, prefer southern. Some spruce and/or hemlock identification group, prefer western wood. Trace of the white pine identification group.

53% Softwood very coarse grade groundwood. Species Douglas-fir and southern and/or jack pine, prefer southern.

Remarks: The groundwood is generally very coarse. Some fines are observed, mostly debris; few fibrillation fines are noted. Numerous partial fibers are observed. Many shives 2-5 fibers thick are seen. The groundwood is much coarser than that from the other cooperators.

The softwood kraft exhibits little or no cutting or fibrillation.

PAPER K

45% Softwood coarse grade groundwood. Species southern and/or jack pine identification group, prefer southern.

33% Softwood lightly bleached kraft. Species southern and/or jack pine identification group, prefer southern. Trace white pine identification group.

20% Hardwood high yield pulp; probable cold soda. Mixed species including maple and/or basswood, populus group, gum, oak and/or chestnut, possibly others.

2% Hardwood bleached kraft. Mixed species including oak and/or chestnut, beech, gum, possibly others.

Remarks: The softwood kraft exhibits little or no cutting or fibrillation.

The high-yield hardwood appears to be quite well defibered.

The softwood groundwood exhibits many fines including both debris and fibrillation fines. Many partial fibers are observed. A few shives, 2-3 fibers thick are seen.

PAPER L

62% Softwood coarse grade groundwood. Species southern and/or jack pine identification group, prefer southern.

36% Softwood lightly bleached kraft. Principal species southern and/or jack pine identification group, prefer southern. Trace white pine identification group

2% Hardwood bleached kraft. Mixed species including gum, yellow poplar, oak and/or chestnut, cucumber magnolia, possibly others.

Remarks: The softwood kraft exhibits little or no cutting or fibrillation.

The groundwood exhibits many fines, both debris and fibrillation fines. Many partial fibers are observed. A few shives are seen.

APPENDIX II

TABLE III

LINTING POTENTIAL OF PAPER J UNDER A VARIETY OF PRINTING CONDITIONS

Run No.	Mfr. and Roll No.	Printing Condition and Type of Plate	Printing Image	Total Impressions	Dampening Solution	Lint Collected: Blanket Lint, g	Ink Train Lint, g	Plate Lint, g[a]	Blanket + Ink Train Lint, g	Total Lint, g	Remarks
1	J1	Offset-plano	Open circle	2500	Acid	1.3144	0.0948	0.0083	1.4092	1.4175	
6	J2	" "	" "	2500	"	0.8788	0.1001	0.0086	0.9789	0.9875	Much lint left blanket to stack
8	J3	" "	" "	2500	"	0.9542	0.0712	0.0057	1.0254	1.0311	Much lint left blanket to stack
Average						1.0491	0.0887	0.0075	1.1378	1.1453	
25	J1	Offset-plano	Open circle	2500	Alkaline	1.6419	0.0764	--	1.7183	--	Blanket lint removal incomplete, little left
24	J1	Offset-plano	Halftone	2500	Acid	1.3036	0.0447	--	1.3483	--	Blanket lint removal incomplete, little left
10	J1	Litho-relief	Open circle	2500	Acid	1.4080	0.3197	0.0210	1.7277	1.7487	Blanket lint removal incomplete, little left
19	J1	" "	" "	2500	"	0.6596	0.3832	0.0273	1.0428	1.0701	
Average						1.0338	0.3514	0.0242	1.3852	1.4094	
13[b]	J1	Letterset-relief	Open circle	2500	--	0.2351	0.3360	0.0645	0.5711	0.6356	Decolorization stop necessary middle of isolation ink train
16	J1	"	" "	2500	--	0.2635	0.2418	0.0556	0.5053	0.5609	
Average						0.2493	0.2889	0.0600	0.5382	0.5982	

[a] The plate lint figures for press runs utilizing a relief plate include some lint which is deposited on the plate cylinder in the nonprinting (open circle) area of the plate. Therefore, these figures are in part inflated.

[b] For this run ink fountain lint was also determined. A weight of 0.0315 g of lint was obtained from what is estimated to be 75% of the contents of the ink fountain.

TABLE IV

LINTING POTENTIAL OF PAPER K UNDER A VARIETY OF PRINTING CONDITIONS

Run No.	Mfr. and Roll No.	Printing Condition and Type of Plate	Printing Image	Total Impressions	Dampening Solution	Lint Collected: Blanket Lint, g	Lint Collected: Ink Train Lint, g	Lint Collected: Plate Lint, g[a]	Lint Collected: Blanket + Ink Train Lint, g	Lint Collected: Total Lint, g	Remarks
2	K1	Offset-plano	Open circle	2500	Acid	0.1532	0.0416	0.0109	0.1948	0.2057	
4	K2	" "	" "	2500	"	0.1689	0.0552	0.0143	0.2241	0.2384	
9	K3	" "	" "	2500	"	0.2295	0.0340	0.0066	0.2635	0.2701	
Average						0.1838	0.0436	0.0106	0.2274	0.2380	
26	K1	Offset-plano	Open circle	2500	Alkaline	0.2973	0.0270	--	0.3243	--	
23	K1	" "	Halftone	2500	Acid	0.1994	0.310	--	0.2304	--	Ink train lint gray, probably due to black ink used previously on press. Two decolorizations necessary during isolation due to clogging of crucible
28	K3	" "	Inked circle	2500	"	0.0767	0.0775	--	0.1542	--	
29E[b]	K2	" "	Open circle	2500	"	0.1526	0.0186	--	0.1712	--	
30[b]	K3	" "	" "	2500	Alkaline	0.1584	0.0436	--	0.2020	--	
31	K3	" "	Inked circle	2500	"	0.0702	0.0657	--	0.1359	--	
32	K3	" "	" "	7500	"	0.0951	0.1946	--	0.2897	--	
33	K2	" "	" "	7500	Acid	0.1682	0.1032	--	0.2714	--	
11	K1	Litho-relief	Open circle	2500	"	0.2003	0.0897	0.0205	0.2900	0.3105	
20	K1	" "	" "	2500	"	0.1924	0.0749	0.0173	0.2673	0.2846	
Average						0.1964	0.0823	0.0189	0.2787	0.2976	Some plate lint lost on isolation
14	K1	Letterset-relief	Open circle	2500	--	0.1736	0.0653	0.0225	0.2389	0.2614	Wax off center blanket lint removal
17	K1	" "	" "	2500	--	0.1420	0.0795	0.0226	0.2215	0.2441	Limited plate lint lost
Average						0.1578	0.0724	0.0225	0.2302	0.2527	

[a] The plate lint figures for press runs utilizing a relief plate include some lint which is deposited on the plate cylinder in the nonprinting (open circle) area of the plate. Therefore, these figures are in part inflated.

[b] Ink fountain lint was determined for press Runs 29 and 30 and found to be 0.0016 and 0.0028 g, respectively.

TABLE V

LINTING POTENTIAL OF PAPER L UNDER A VARIETY OF PRINTING CONDITIONS

Run No.	Mfr. and Roll No.	Printing Condition and Type of Plate	Printing Image	Total Impressions	Dampening Solution	Lint Collected: Blanket Lint, g	Ink Train Lint, g	Plate Lint, g[a]	Blanket + Ink Train Lint, g	Total Lint, g	Remarks
3	L1	Offset-plano	Open circle	2500	Acid	0.2132	0.0968	0.0161	0.3100	0.3261	
5	L2	" "	" "	2500	"	0.1872	0.0708	0.0145	0.2580	0.2725	
7	L3	" "	" "	2500	"	0.2833	0.0652	0.0090	0.3485	0.3575	
Average						0.2279	0.0776	0.0132	0.3055	0.3187	
27	L1	" "	" "	2500	Alkaline	0.3770	0.0272	--	0.4042	--	
22	L1	" "	Halftone	2500	Acid	0.2511	0.0258	--	0.2769	--	Ink train lint gray, probably due to use of black ink used previously on press
12	L1	Litho-relief	Open circle	2500	"	0.2363	0.1035	0.0264	0.3398	0.3662	Plate lint filtered with difficulty
21	L1	" "	" "	2500	"	0.1447	0.0871	0.0190	0.2318	0.2508	Some wax picked to blanket
Average						0.1905	0.0953	0.0227	0.2858	0.3085	
15	L1	Letterset-relief	" "	2500	--	0.1899	0.0565	0.0236	0.2464	0.2700	
18	L1	" "	" "	2500	--	0.1890	0.0578	0.0214	0.2468	0.2682	
Average						0.1895	0.0571	0.0225	0.2466	0.2691	

[a]The plate lint figures for press runs utilizing a relief plate include some lint which is deposited on the plate cylinder in the nonprinting (open circle) area of the plate. Therefore, these figures are in part inflated.

APPENDIX III

COMPARISON OF PRESS PRINTS WITH PLATE AND BLANKET LINT PHOTOGRAPHS